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NAS PENSACOLA
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LETTER AND RESPONSES FROM U S NAVY REGARDING NATIONAL OCEANOGRAPHIC AND ATMOSPHERIC ADMINISTRATION TECHNICAL REVIEW OF SAMPLING REPORT SITE 40 NAS PENSACOLA FL

8/9/2002

U S NAVY

National Oceanographic and Atmospheric Administration (NOAA)
Response to Technical Comments
Site 40 Sampling Report
NAS Pensacola

August 9, 2002

Report's Findings

The 1996 RI results indicated unacceptable risks (i.e., HQ>1) to higher trophic level fish due to mercury in Site 40 (Bayou Grande) sediments near PNS NAS (see upper portion of Table 5 in subject report). To reduce uncertainty in the fish exposure model, site-specific data was collected in 2001. Synoptic sediment and prey fish samples were collected at seven of the 1996 RI stations and analysed for mercury. Site-specific results reveal the following.

a. Sediment mercury concentrations have decreased at 5 stations, increased at Station 216 and stayed about the same at Station 247 (see lower portion of Table 5).

b. Where mercury concentrations have decreased, no unacceptable risks exist for higher trophic level fish based on modelled results (lower portion of Table 5).

c. At the two stations where mercury concentrations increased or stayed the same, site-specific prey fish results decreased projected risks from HQs of about 5 (lower portion of Table 5) to HQs $\approx$ 2 (Table 6).

Recommendations

Use residue-based mercury NOAEL and LOAEL values recently developed in Region 4 (see attached electronic files). The NOAEL (0.15 mg/kg) is slightly *higher* than the NOED used in the subject report. Estimating risks based on the NOAEL and LOAEL values will identify ecologically protective levels as suggested in EPA guidance. I have calculated protective levels below using the 2001 site-specific data and attached NOAEL/LOAEL values.

RI Station	NOAEL HQ (0.15 mg/kg)	LOAEL HQ (0.30 mg/kg)
040MZ130	0.42	0.21
040MZ216	1.7	0.84
040MZ237	0.63	0.32
040MZ244	0.11	0.06
040MZ247	1.7	0.86

040MZ316	0.50	0.26
040MZ401[a]	0.05	0.02

[a] No site-specific prey fish were collected at Station 401. Therefore, estimated risks are based on modelled exposure in Table 5.

Response:

Agreed. The 0.15 mg/kg NOAEL value and 0.30 mg/kg LOAEL will be used in lieu of the 0.14 mg/kg NOED value.

Comment:

Eliminate use of Site-Foraging Factor (SFF). The subject report calculates risks assuming a SFF of 1 and 0.32. The latter is presumably based on the length of PNS NAS shoreline relative to the entire bayou. It assumes higher trophic level fish forage equally throughout the bayou. This has not been demonstrated. In fact, one could strongly argue that higher trophic level fish forage *preferentially* at PNS NAS because it's less developed than the rest of the bayou.

Rather than using an undocumented SFF to "eliminate" the projected risks at Stations 216 and 247, provide a narrative in the uncertainty section discussing the size of PNS NAS relative to Bayou Grande. Then discuss the uncertainty of where higher trophic level fish forage. The risk manager can then decide whether the level of projected risks and the uncertainty associated with foraging areas merit a conclusion of no unacceptable ecological risk.

Response:

Agreed. The SFF for the Red Drum will be removed from the HQ calculations.

Comment:

Eliminate the entire uncertainty section as currently written. Atmospheric deposition of mercury is not germane to the current risk assessment for higher trophic level fish. A discussion of atmospheric deposition will confuse rather than provide clarity to the reader.

Response:

Agreed. The atmospheric mercury discussion will be removed from the document.

Comment:

Eliminate the "offsite background" sample (Station 237). As with the atmospheric discussion, the background sample results provide no additional insight and will confuse rather than clarify the primary purpose of the analysis. The term "upstream" (page 1) is probably not appropriate terminology for a low energy, estuarine water body such as Bayou Grande.

Response:

The Navy disagrees with this recommendation. The background location was sampled at an agreed upon offsite location and indicates that mercury concentrations at Site 40 are not elevated because of activities at NAS Pensacola.

Table 6

Even though prey fish were not collected at Station 401, calculate risks to higher trophic level fish based on sediment alone. Footnote [b] appears incorrect.

Response:

Agreed. This footnote is incorrect and will be corrected.

Comment:

For the fish samples, report size and number of fish in each composite as well as percent lipids.

Response:

Agreed. Table 4 will be modified to incorporate this data.

FINAL REMEDIAL INVESTIGATION REPORT
ADDENDUM 2 — SITE 40 — BAYOU GRANDE
NAVAL AIR STATION
PENSACOLA, FLORIDA

SOUTHNAVFACENGCOM
CONTRACT NUMBER:
N62467-89-D-0318

CTO — 036

Prepared for:

Comprehensive Long-Term
Environmental Action Navy
Naval Air Station
Pensacola, Florida

Prepared by:

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The contractor, EnSafe Inc., hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0318 are complete, accurate, and comply with all requirements of the contract.

Date: August 9, 2002
Signature: Allison Harris
Name: Allison Harris
Title: Task Order Manager

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19. Abstract

This addendum presents results from a 2001 investigation of mercury contamination in forage fish in Bayou Grande (Site 40), Operable Unit 15, at the Naval Air Station (NAS) Pensacola, Florida. The additional sediment and fish sampling at Site 40 was conducted to reduce the uncertainty within the upper trophic level fish model presented in the Site 40 *Final RI Report Addendum* (EnSafe, April 24, 2000). This fish model is the Red Drum *(Sciaenops ocellatus)* Mercury Bioaccumulation Model developed by Evans and Engel (May, 1994), which estimates the transfer of mercury from sediment to forage fish to red drum (predatory fish). Seven Phase II sample locations (1996 samples) from the Site 40 RI were selected for re-sampling. Sediment samples were collected from these locations for mercury and TOC analyses. Forage fish were also collected from these locations for whole tissue analyses for mercury and percent lipids.

Sediment mercury results were compared to the USEPA/FDEP sediment benchmark level of 0.13 ppm. HQs were calculated for each location. Sediment mercury results showed decreases at four 1996 sample locations to HQs below 1 in 2001. Two 2001 sample locations had sediment mercury HQs greater than 1; one of these showed an increase from 1996.

Forage fish were collected from six of the seven sample locations (one location did not have an appropriate habitat for forage fish). Both sediment and whole fish-tissue mercury results were used to estimate predatory fish mercury concentrations using the Evans and Engel Model. Both 1996 and 2001 sediment results are presented in this document. The sediment mercury results were modeled to estimate the methyl mercury tissue concentration in predatory fish, while the prey fish tissue mercury results provided an exact measurement for use in the Model. The modeled results were compared to the USEPA NOAEL of 0.15 ppm and the LOAEL of 0.30 ppm (Appendix A).

In comparing the HQs based on sediment mercury detections in 1996 and 2001, risk predicted for red drum has decreased at six of the seven sample locations, with an increase at one location. The maximum onsite NOAEL HQ based on model results from sediment concentrations decreased from 37.69 in 1996 to 4.45 in 2001. HQs based on the results from the actual forage fish data indicate a maximum NOAEL HQ of 1.72 and a maximum LOAEL HQ of 0.86 at onsite locations. This indicates that the model conservatively estimated risk to predatory fish from sediment concentrations.

The NOAEL HQs based on sediment concentrations have decreased substantially from 1996 to 2001. Only two onsite locations (040MZ216 and 040MZ247) have HQs greater than 1 from the measured prey fish concentrations. All of the onsite LOAEL HQs are below 1 from the 2001 sampling event. None of the IRP sites investigated at NAS Pensacola have been associated with mercury contamination. This study conservatively estimates the risk to the red drum by assuming the fish will spend all of their life in Bayou Grande and at Site 40. Therefore, excess risk is not predicted for predatory fish based on the detected concentrations at Site 40.

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EXECUTIVE SUMMARY

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Forage fish were collected from six of the seven sample locations (one location did not have an appropriate habitat for forage fish). Both sediment and whole fish-tissue mercury results were used to estimate predatory fish mercury concentrations using the Evans and Engel Model. Both 1996 and 2001 sediment results are presented in this document. The sediment mercury results were modeled to estimate the methyl mercury tissue concentration in predatory fish, while the prey fish tissue mercury results provided an exact measurement for use in the Model. The modeled results were compared to the USEPA NOAEL of 0.15 ppm and the LOAEL of 0.30 ppm (Appendix A).

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The NOAEL HQs based on sediment concentrations have decreased substantially from 1996 to 2001. Only two onsite locations (040MZ216 and 040MZ247) have HQs greater than 1 from the measured prey fish concentrations. All of the onsite LOAEL HQs are below 1 from the 2001 sampling event. None of the IRP sites investigated at NAS Pensacola have been associated with mercury contamination. This study conservatively estimates the risk to the red drum by assuming the fish will spend all of their life in Bayou Grande and at Site 40. Therefore, excess risk is not predicted for predatory fish based on the detected concentrations at Site 40.

1.0 INTRODUCTION

This report presents results from an investigation for mercury contamination in forage fish in Bayou Grande (Site 40), Operable Unit 15, at the Naval Air Station (NAS) Pensacola, Florida.

2.0 BACKGROUND

Site 40, also known as Bayou Grande, is an estuarine water body adjacent to the northern border of NAS Pensacola in Escambia County. Bayou Grande extends roughly east to west approximately 5 miles inland into the south-southwestern portion of Escambia County. The northern and central portions of NAS Pensacola, and the areas of west Warrington adjacent to the bayou, drain into the bayou. Bayou Grande flows eastward into Pensacola Bay near NAS Pensacola's Magazine Point. The total surface area covered by Site 40 is currently used for swimming, fishing, and other boating activities. Seasonal water temperatures limit swimming to the warmer months, while fishing is generally a year-round activity.

Previous investigations at Site 40 included a Phase II assessment of nearshore sediments in 1996. In 1998, prey fish were collected and analyzed for pesticides and polychlorinated biphenyls (PCBs). Based on the results of the Site 40 baseline risk assessment as presented in the *Final Remedial Investigation (RI) Report* (EnSafe, 1999), these compounds were found to pose a potential risk to human health as a result of ingestion of contaminated fish species that inhabit Bayou Grande. A more detailed risk assessment was conducted for the fish ingestion pathway using site-specific values. The results of the site-specific risk assessment for the fish ingestion exposure pathway at Site 40 was presented in the *Final RI Report Addendum* (EnSafe, April 24, 2000). The *Final RI Report Addendum* determined that risks associated with the ingestion of contaminated fish are within acceptable limits. However, mercury concentrations in predatory fish were not based on measured results, but were estimated based on detections in sediment. The modeled results indicated a potential excess risk to predatory fish. Therefore, an agreement was reached to sample forage fish and sediment for mercury to validate the model results.

The *Technical Memorandum* of June 27, 2001 presented the rationale and procedures to address the previously identified data gaps. The memorandum presented a plan to conduct further sediment and fish sampling at Site 40 to reduce the uncertainty within the upper trophic level fish model presented in the Site 40 *Final RI Report Addendum* and the uncertainty within the ecological risk assessment for predatory fish. This fish model is the Red Drum *(Sciaenops ocellatus)* Mercury Bioaccumulation Model developed by Evans and Engel (May, 1994), which estimates the transfer of mercury from sediment to forage fish to predatory fish.

3.0 FIELD SAMPLING

Field sampling was conducted during August of 2001. The *Technical Memorandum* outlines how seven Phase II sample locations from the Site 40 RI were selected for re-sampling based on an evaluation of Phase II mercury and total organic carbon (TOC) results. Locations were selected to represent a range of low-to-high mercury and TOC detections. In addition, an offsite location was selected approximately 0.87 miles west of the NAS Pensacola boundary. Sediment samples from each location were collected and analyzed for total mercury, and TOC analyses. Forage fish samples were also collected for whole tissue analysis of mercury and percent lipids. Figure 1 shows the sample locations. Table 1 summarizes the samples collected and the analyses performed. Analytical results are presented in Appendix A.

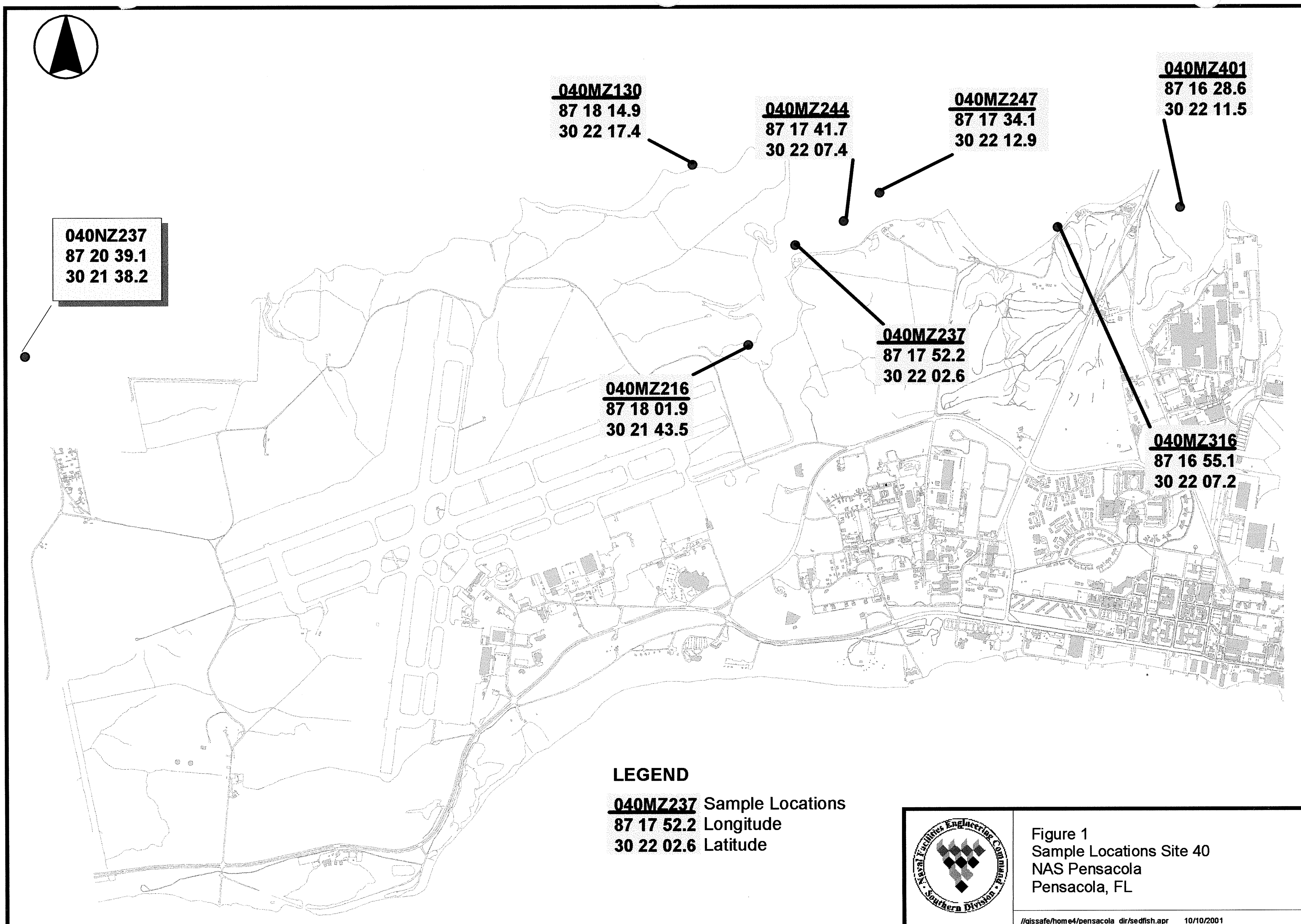

Figure 1
Sample Locations Site 40
NAS Pensacola
Pensacola, FL

Table 1
Site 40 Sample Locations and Analyses

Sample Location	Sediment Analyses	Fish Tissue Analyses	Remarks
040MZ130	Hg; TOC	Hg; % Lipids	
040MZ216	Hg; TOC	Hg; % Lipids	Duplicate also collected.
040MZ237	Hg; TOC	Hg; % Lipids	
040MZ244	Hg; TOC	Hg; % Lipids	
040MZ247	Hg; TOC	Hg; % Lipids	
040MZ316	Hg; TOC	Hg; % Lipids	
040MZ401	Hg; TOC	No fish available	
040NZ237	TAL Metals; AVS-SEM; TOC	Full Scan; % Lipids	Site 40 offsite sample

Notes:
TOC = Total organic carbon.
% Lipids = Percent lipids in fish tissue.
TAL = Target Analyte List
AVS-SEM Acid Volatile Sulfide-Simultaneously Extracted Metal

Table 2 presents the sediment mercury results for the 2001 sampling, and compares these to the Site 40 Phase II sediment results (1996 results) for the same sample locations. Using a sediment benchmark level of 0.13 parts per million (ppm) (McDonald, D.D., 1994; United States Environmental Protection Agency [USEPA], 1995), hazard quotients (HQs) were calculated for each location. An HQ exceeding 1 indicates a potential for excess risk from mercury in sediment. As shown in Table 2, mercury concentrations in sediment decreased from 1996 to 2001 (the table reflects ½ the detection limit for those samples where mercury was non-detect). Four sample locations with mercury HQs greater than 1 in 1996 (040MZ130, 040MZ244, 040MZ316, and 040MZ401) had HQs below 1 in 2001. Only two 2001 sample locations (040MZ216 and 040MZ247) had HQs greater than 1 (1.85 and 2) and only one sample 040MZ216 showed an increase from 1996 (1996 mercury HQ — 0.23; 2001 mercury HQ — 1.85).

Table 2
Comparison of Mercury Results in Sediment
Site 40

Sample Location	1996 Results (ppm)	HQ[a]	2001 Results (ppm)	HQ[a]
040MZ130	2.2	16.92	0.0025[b]	0.02
040MZ216	0.03[b]	0.23	0.24	1.85
040MZ237	0.08	0.62	0.01	0.08
040MZ244	0.64	4.92	0.0031[b]	0.02
040MZ247	0.28	2.15	0.26	2.0
040MZ316	0.14	1.08	0.0027[b]	0.02
040MZ401	0.155[b]	1.19	0.0028[b]	0.02
040NZ237	NS	NA	0.011	0.09

Notes:
a = HQs based on a sediment benchmark level of 0.13 ppm.
b = Results were non-detect; number reflects ½ the non-detect value.
ppm = Parts per million.

Fish Tissue

Fish sampling was conducted as outlined in the *Technical Memorandum*. Pinfish *(Lagodon rhomboides)* were collected from four sample locations, while striped mullet *(Mugil cephalus)* were collected from two locations. At all locations, the smallest size pinfish or mullet were selected to represent forage fish. No fish were collected at sample location 040MZ401; attributed to a lack of appropriate habitat for forage fish at this location. Table 3 presents the fish tissue mercury results for the Site 40 samples. The table also presents the percent lipid analyses and supplementary information related to the fish sampling.

Table 3
Fish Tissue Mercury Results
Site 40

Sample Location	Fish Species Collected	Number/Size of Fish Collected	Mercury in Fish Tissue (ppm)	Percent Lipids
040MZ130	Pinfish	Approx. 30/1.5"	0.042	0.59
040MZ216	Striped Mullet	2 ea./2"	0.033	0.34
040MZ237	Pinfish	Approx. 30/1.5"	0.06	0.38
040MZ244	Striped Mullet	2 ea./2"	0.01[a]	0.47
040MZ247	Pinfish	Approx. 30/1.5"	0.026	1.3
040MZ316	Pinfish	Approx. 30/1.5"	0.052	1.1
040MZ401	No fish collected	—	—	—
040NZ237	Pinfish	3 ea./1"-3"	0.32	0.58

Notes:
a = Results were non-detect; number reflects ½ the non-detect value.
ppm = Parts per million.

4.0 RED DRUM MERCURY EXPOSURE MODEL

4.1 Background

A model was performed which predicts mercury tissue concentrations in the red drum based on concentrations of mercury in the sediment of Site 40. This model is based on the red drum mercury bioaccumulation model developed by Evans and Engel. The model assumes that mercury uptake into the red drum occurs via prey ingestion exclusively. The three prey sources are forage fish, crustaceans, and infaunal invertebrates. The Site 40 *Final RI Report Addendum* and Evans and Engel explain this model in detail.

The equation used in the model is briefly explained below:

$$= \left(\frac{a * R}{g + K}\right) * \left[(Cf)(\%Cf) + (Ccr)(\%Ccr) + (Cinv)(\%Cinv)\right]$$

where:

a	=	Assimilation efficiency of mercury from food, or 0.8.
R	=	Feeding rate of the red drum, or 0.02/day.
g	=	growth rate coefficient, or 0.003/day.
K	=	Methyl mercury excretion rate from the red drum, or 0.00035/day.
Cf	=	Methyl mercury tissue concentration in forage fish.
$\%Cf$	=	Percent of red drum diet composed of forage fish, or 0.3.
Ccr	=	Methyl mercury tissue concentration in crustaceans.
$\%Ccr$	=	Percent of red drum diet composed of crustaceans, or 0.6.
$Cinv$	=	Methyl mercury tissue concentrations in infaunal benthic invertebrates.
$\%Cinv$	=	Percent of red drum diet composed of benthic invertebrates, or 0.1.

The first part of the mercury model equation calculates the bioaccumulation factor for methyl mercury, adjusting for input and excretion of this metal (which are assumed to be in balance at steady state). The second portion of the equation estimates the accumulation of methyl mercury from the prey pathway, based on the assumption of a diet comprised of 30% forage fish, 60% crustaceans, and 10% infaunal invertebrates. The Site 40 *Final RI Report Addendum* and Evans and Engel also explain how *Cf*, *Ccr*, and *Cinv* are calculated. These are briefly reviewed below:

$$Cf = (1.2)(Cs)$$

$$Ccr = \left[\frac{(Cs*2)}{5}\right]*(0.70)$$

$$Cinv = \left[\frac{(Cs*2)}{5}\right]*(0.25)$$

Where: Cs = the total mercury (in ppm) in sediment. The Site 40 *Final RI Report* and Evans and Engel explain the other coefficients used in the above formulae.

4.2.1 Site 40 Modeling Results

Table 4 presents the mercury sediment results for each of the Site 40 sampling locations to calculate the mercury in the red drum using the Evans and Engel model. The calculated concentration is then compared to the no observable adverse effects level (NOAEL) and the lowest observable adverse effects level (LOAEL). Table 4 also presents the red drum mercury calculations for the 1996 sediment mercury results, and compares these to the 2001 results for the same sample locations. As shown in the table, risk predicted for the red drum in Bayou Grande from the 1996 sediment data ranged between NOAEL HQs of 0.51 (040MZ216) and 37.69 (040MZ130). Risk predicted for the red drum in the bayou from the 2001 sediment data ranged between NOAEL HQs of 0.04 (040MZ130) to 4.45 (040MZ247). The data show a decrease in red drum mercury HQs at six of seven sample locations from 1996 to 2001, with an increase at location 040MZ216. The maximum NOAEL HQ decreases from 37.69 (040MZ130) to 4.45 (040MZ247) between these years. This decrease is attributable to the lower detections of mercury found in the 2001 sediment samples, and demonstrates a substantial decrease in predicted risk for the red drum since the 1996 sampling effort.

Table 4
Mercury in Upper Trophic Level Fish
Red Drum Mercury Model — Mercury in Forage Fish Estimated

Sample Location	Hg in Sediment (Cs) (ppm)	Hg in Forage Fish[b] (Cf) (ppm)	Hg in Crustaceans (Ccr) (ppm)	Hg in Invertebrates (Cinv) (ppm)	Hg in Red Drum Tissue (ppm)	NOAEL HQ	LOAEL HQ
1996 Results							
040MZ130	2.2	2.64	0.616	0.22	5.653	37.69	18.8
040MZ216	0.03[a]	0.036	0.008	0.003	0.077	0.51	0.26
040MZ237	0.08	0.096	0.022	0.008	0.206	1.37	0.69
040MZ244	0.64	0.768	0.179	0.064	1.645	10.96	5.48
040MZ247	0.28	0.336	0.078	0.026	0.720	4.8	2.4
040MZ316	0.14	0.168	0.039	0.014	0.360	2.4	1.2
040MZ401	0.155[a]	0.186	0.043	0.016	0.398	2.66	8.85
2001 Results							
040MZ130	0.0025[a]	0.003	0.001	0.0003	0.006	0.04	0.02
040MZ216	0.24	0.288	0.067	0.024	0.617	4.11	2.06
040MZ237	0.01	0.012	0.001	0.001	0.026	0.17	0.09
040MZ244	0.0031[a]	0.004	0.0009	0.0003	0.008	0.05	0.03
040MZ247	0.26	0.312	0.073	0.026	0.668	4.45	2.23
040MZ316	0.0027[a]	0.0032	0.00076	0.00027	0.0069	0.05	0.02
040MZ401	0.0028[a]	0.0034	0.00078	0.00028	0.0072	0.05	0.024
040NZ237 (offsite location)	0.011	0.0132	0.00308	0.0011	0.02827	0.189	0.095

Notes:

a = Results were non-detect; number reflects ½ the non-detect value.
b = Results derived by estimating the mercury concentration in forage fish using the appropriate calculation from the Red Drum Mercury Model.
HQ = Hazard Quotient.
NOAEL = No Observable Adverse Effects Level of 0.15 ppm (NOAA 2001)
LOAEL = Lowest Observable Adverse Effects Level of 0.30 ppm (NOAA 2001)
ppm = Parts per million.

Table 5
Mercury in Upper Trophic Level Fish
Red Drum Mercury Model—Mercury in Forage Fish Measured

Sample Location	Hg in Sediment (Cs) (ppm)	Hg in Forage Fish[c] (ppm)	Hg in Crustaceans (Ccr) (ppm)	Hg in Invertebrates (Cinv) (ppm)	Hg in Red Drum Tissue (ppm)	NOAEL HQ	LOAEL HQ
040MZ130	0.0025[b]	0.042	0.001	0.0003	0.062	0.42	0.21
040MZ216	0.24	0.033	0.0672	0.024	0.251	1.66	0.84
040MZ237	0.01	0.06	0.003	0.001	0.095	0.63	0.32
040MZ244	0.0031[b]	0.01[a]	0.001	0.0003	0.017	0.11	0.06
040MZ247	0.26	0.026	0.073	0.026	0.258	1.72	0.86
040MZ316	0.0027[b]	0.052	0.0008	0.0003	0.077	0.51	0.26
040MZ401[a]	0. 0028[b]	0.003	0.0008	0.0003	0.007	0.05	0.02
040NZ237 (offsite location)	0.011	0.032	0.0031	0.0011	0.468	3.342	1.56

Notes:

a = No forage fish were collected at location 040MZ401. The estimated value of mercury in forage fish from Table 4 for this location is substituted for comparison.
b = Results were non-detect; number reflects ½ the non-detect value.
c = Results derived from whole fish tissue analysis.
HQ = Hazard Quotient.
NOAEL = No observable Adverse Effects Level of 0.15 ppm (NOAA 2001).
LOAEL = Lowest observable Adverse Effects Level of 0.30 ppm (NOAA 2001).
ppm = parts per million.

For the 2001 sampling, the Evans and Engel model was also run using actual forage fish tissue mercury data obtained from the fish collected at each sample location. Table 5 presents these data. As shown in the table, risk predicted for the red drum in Site 40 from the actual 2001 forage fish tissue data ranged between NOAEL HQs of 0.11 (040MZ244) and 1.72 (040MZ247) with the NOAEL. The offsite location had a calculated NOAEL HQ of 3.34. Except for the offsite location, all HQs are below 1 when compared to the LOAEL. No fish were collected at sample location 040MZ401; however, the estimated values for this sample from Table 4 are also presented in Table 5 for comparison. As can be seen from the data, the red drum model predicts a much lower risk for Site 40 using actual forage-fish tissue mercury data in place of estimated fish tissue mercury data.

The modeling of the 2001 sediment and fish tissue mercury data substantiate the overall reduction in mercury concentrations in Bayou Grande since 1996, and the decreased risk predicted for predatory level fish at Site 40. Figure 2 shows the sediment HQs and red drum NOAEL HQs and LOAEL HQs for each sample location.

5.0 UNCERTAINTIES

5.1 The Lack of Mercury Sources at NAS Pensacola

Though there were some mercury detections in sediment and surface water samples from the Site 41 wetlands bordering Site 40, this mercury is not attributable to any Installation Restoration Program (IRP) site at NAS Pensacola. A review of historical environmental documents for the base revealed that there have been no process streams involving mercury at any IRP site. Field sampling at the sites investigated thus far has revealed isolated detections of mercury above USEPA and FDEP standards, but none of these investigations have required development of remedial alternatives to address mercury contamination. None of the IRP sites still under review are awaiting disposition because of mercury contamination.

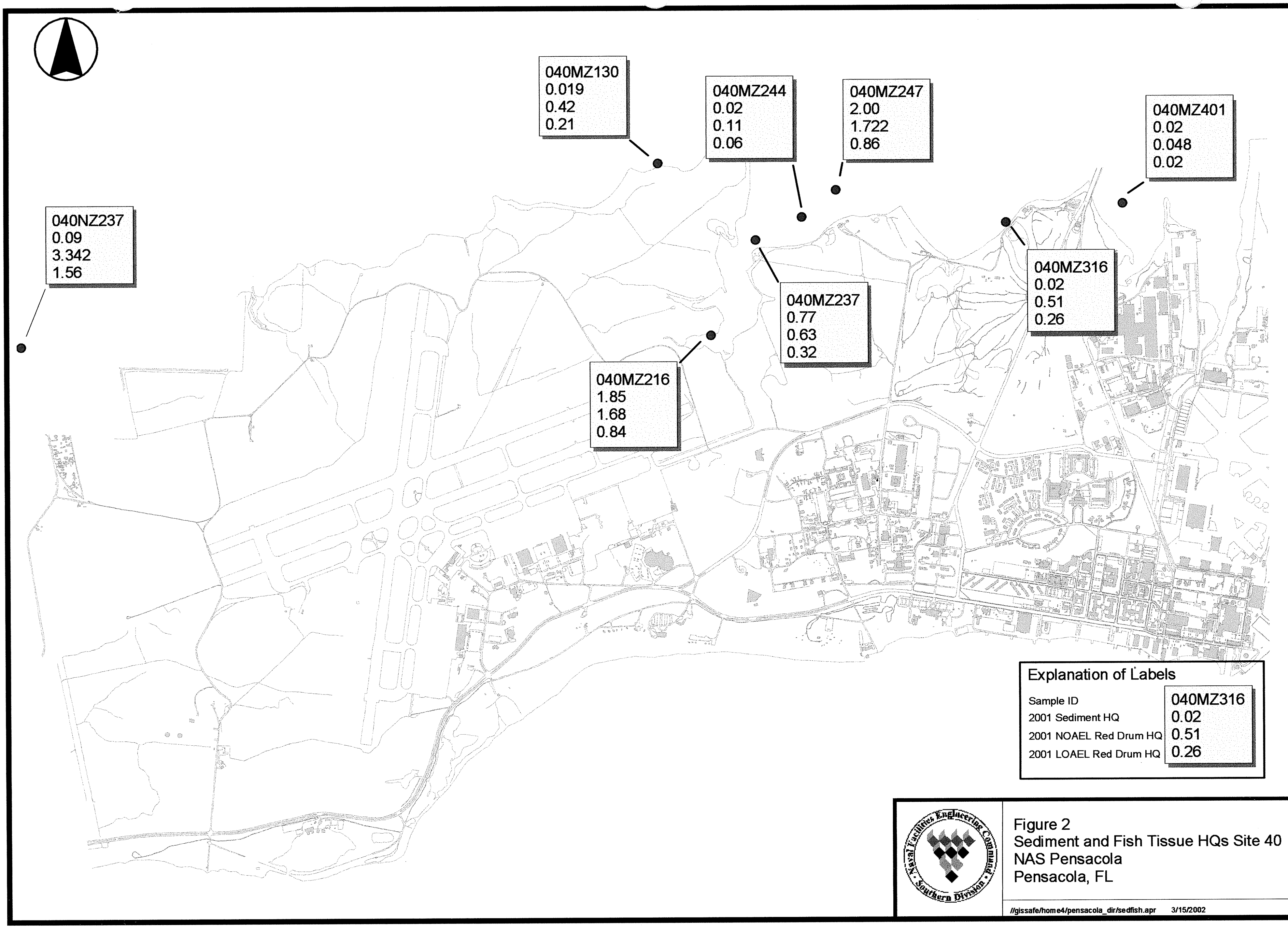

Figure 2
Sediment and Fish Tissue HQs Site 40
NAS Pensacola
Pensacola, FL

//gissafe/home4/pensacola_dir/sedfish.apr 3/15/2002

5.2 Red Drum Feeding Range Within Site 40

The Site 40 *Final RI Report Addendum* (EnSafe, April 24, 2000) details how red drum are dependent on estuaries for at least the first few years of life. Larvae and juveniles are generally found in shallow waters, in areas not greatly affected by tides, with grassy or muddy bottoms and moderate salinities. Adult red drum migrate to nearshore ocean waters and only come back to the estuaries to spawn. They would therefore likely spend the majority of time in nearshore ocean waters, only coming back to Bayou Grande to spawn; primarily feeding on prey from Pensacola Bay and the Gulf of Mexico (EnSafe, April 24, 2000).

Further, this model assumes that the red drum forages in the Site 40 area of Bayou Grande for its entire life. Using 300 feet from the NAS Pensacola shoreline on Bayou Grande as the outer boundary for all of Site 40 corresponds to a total surface area of approximately 310 acres for Site 40 (EnSafe, April 24, 2000). Site 40 therefore comprises about one-third of Bayou Grande's surface area of approximately 960 acres. This may lead to an overestimation of potential risk.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The NOAEL HQs based on sediment concentrations have decreased substantially from 1996 to 2001. Only two onsite locations (040MZ216 and 040MZ247) have HQs greater than 1 calculated from the measured prey fish concentrations. All of the onsite LOAEL HQs are below 1 from the 2001 sampling event. None of the IRP sites investigated at NAS Pensacola have been associated with mercury contamination. This study conservatively estimates the risk to the red drum by assuming the fish will spend all of their life in Bayou Grande and at Site 40. Therefore, excess risk is not predicted for predatory fish based on the detected concentrations at Site 40.

7.0 REFERENCES

EnSafe Inc. (April 24, 2000). *Final Remedial Investigation Report Addendum Site 40 — Bayou Grande — NAS Pensacola.* NAS Pensacola, Florida.

EnSafe Inc. (June 27, 2001). Recommendation for Mercury Sampling, Site 40 and Wetland 64. Technical Memorandum. NAS Pensacola, Florida.

Evans, D.W., and Engel, D.W. (May 1994). *Mercury Bioaccumulation in Finfish and Shellfish from Lavaca Bay, Texas: Descriptive Models and Annotated Bibliography.* NOAA Tech. Mem. NMFS-SEFSC-348, 89p.

MacDonald, D.D. (1994). *Approach to the Assessment of Sediment Quality in Florida Coastal Waters; Volume 1 — Development and Evaluation of Sediment Quality Assessment Guidelines.* Florida Department of Environmental Protection, Office of Water Policy. Tallahassee, FL.

NEESA. (June, 1983). *Initial Assessment Study of Naval Air Station, Pensacola, Florida.* (NEESA 13-015).

U.S. Environmental Protection Agency. (1995). *Supplemental Guidance to RAGS: Region IV Bulletins — Ecological Screening Values,* Ecological Risk Assessment Bulletin No. 2. USEPA Region IV. Atlanta, GA.

Appendix A
Analytical Results

Prey Fish Analytical Results

5102 LaRoche Avenue • Savannah, GA 31404 • Tel: 912 354 7858 • Fax: 912 352 0165 • www.stl-inc.com

SEVERN TRENT SERVICES
STL Savannah

LOG NO: S1-15006A
Received: 07 AUG 01
Reported: 31 AUG 01

Ms. Tina Cantwell
EnSafe, Inc.
5724 Summer Trees Drive
Memphis, TN 38134

Client PO. No.: 4255

Requisition: 0059-001-08-600-00
Contract No.: 0036-001-00-130-00
Project: NAS Pensacola/SDG#NASP15
Sampled By: Client
Code: 13391095

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , BIOLOGICAL TISSUE SAMPLES	DATE/ TIME SAMPLED	SDG#
15006A-1	041J640301	08-02-01	NASP15
15006A-2	041J640301-K	08-02-01	NASP15
15006A-3	041J640602	08-02-01	NASP15
15006A-4	041J640302	08-02-01	NASP15
15006A-5	040MZ21602	08-02-01	NASP15

PARAMETER	15006A-1	15006A-2	15006A-3	15006A-4	15006A-5
% Lipids,	1.2 %	1.1 %	0.92 %	0.71 %	0.34 %
Dilution Factor	1	1	1	1	1
Prep Date	08.10.01	08.10.01	08.10.01	08.10.01	08.10.01
Analysis Date	08.13.01	08.13.01	08.13.01	08.13.01	08.13.01
Batch ID	0810A	0810A	0810A	0810A	0810A

SEVERN TRENT SERVICES
STL Savannah
5102 LaRoche Avenue • Savannah, GA 31404 • Tel: 912 354 7858 • Fax 912 352 0165 • www.stl-inc.com

LOG NO: S1-15006A
Received: 07 AUG 01
Reported: 31 AUG 01

Ms. Tina Cantwell
EnSafe, Inc.
5724 Summer Trees Drive
Memphis, TN 38134

Client PO. No.: 4255

Requisition: 0059-001-08-600-00
Contract No.: 0036-001-00-130-00
Project: NAS Pensacola/SDG#NASP15
Sampled By: Client
Code: 13391095

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , BIOLOGICAL TISSUE SAMPLES	DATE/ TIME SAMPLED	SDG#
15006A-6	041M640202	08-02-01	NASP15
15006A-7	041J642401	08-02-01	NASP15
15006A-8	041J640501	08-02-01	NASP15
15006A-9	041J640701	08-02-01	NASP15
15006A-10	040NZ23702	08-02-01	NASP15

PARAMETER	15006A-6	15006A-7	15006A-8	15006A-9	15006A-10
% Lipids,	0.34 %	0.41 %	0.50 %	1.3 %	0.58 %
Dilution Factor	1	1	1	1	1
Prep Date	08.10.01	08.10.01	08.10.01	08.10.01	08.10.01
Analysis Date	08.13.01	08.13.01	08.13.01	08.13.01	08.13.01
Batch ID	0810A	0810A	0810A	0810A	0810A

SEVERN TRENT SERVICES
STL Savannah
5102 LaRoche Avenue • Savannah, GA 31404 • Tel: 912 354 7858 • Fax: 912 352 0165 • www.stl-inc.com

LOG NO: S1-15006A
Received: 07 AUG 01
Reported: 31 AUG 01

Ms. Tina Cantwell
EnSafe, Inc.
5724 Summer Trees Drive
Memphis, TN 38134

Client PO. No.: 4255

Requisition: 0059-001-08-600-00
Contract No.: 0036-001-00-130-00
Project: NAS Pensacola/SDG#NASP15
Sampled By: Client
Code: 13391095

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , BIOLOGICAL TISSUE SAMPLES	DATE/ TIME SAMPLED	SDG#
15006A-11	040JZ24701	08-02-01	NASP15
15006A-12	040MZ24401	08-02-01	NASP15
15006A-13	040MZ13002	08-02-01	NASP15
15006A-14	040MZ23702	08-02-01	NASP15
15006A-15	040JZ31601	08-02-01	NASP15

PARAMETER	15006A-11	15006A-12	15006A-13	15006A-14	15006A-15
% Lipids,	1.3 %	0.47 %	0.59 %	0.38 %	1.1 %
Dilution Factor	1	1	1	1	1
Prep Date	08.10.01	08.10.01	08.10.01	08.10.01	08.10.01
Analysis Date	08.13.01	08.13.01	08.13.01	08.13.01	08.13.01
Batch ID	0810A	0810A	0810A	0810A	0810A

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.
040~~M~~J Z13002

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP15

Matrix (soil/water): SOIL Lab Sample ID: S115006A-13

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.042	B		CV

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments:

tissue

TOTAL METALS

-1-

INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.

040MZ21602
J

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP15

Matrix (soil/water): SOIL Lab Sample ID: S115006A-5

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	110			P
7440-36-0	Antimony	0.42	U		P
7440-38-2	Arsenic	1.3			P
7440-39-3	Barium	1.1			P
7440-41-7	Beryllium	0.010	U		P
7440-43-9	Cadmium	0.050	U		P
7440-70-2	Calcium	8900		*	P
7440-47-3	Chromium	1.1			P
7440-48-4	Cobalt	0.080	U		P
7440-50-8	Copper	1.6	B		P
7439-89-6	Iron	330			P
7439-92-1	Lead	1.4			P
7439-95-4	Magnesium	460			P
7439-96-5	Manganese	5.3			P
7439-97-6	Mercury	0.033	B		CV
7440-02-0	Nickel	0.14	U		P
7440-09-7	Potassium	2800			P
7782-49-2	Selenium	0.80	B		P
7440-22-4	Silver	0.070	U		P
7440-23-5	Sodium	1500			P
7440-28-0	Thallium	0.45	U		P
7440-62-2	Vanadium	0.63	B		P
7440-66-6	Zinc	18			P

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

C ents:

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.
040MZ23702

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP15

Matrix (soil/water): SOIL Lab Sample ID: S115006A-14

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.060	B		CV

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments:

tissue

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.
040MZ24401

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP15

Matrix (soil/water): SOIL Lab Sample ID: S115006A-12

Level (low/med): LOW Date Received: 07-AUG-2001

Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.020	U		CV

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments:

SW-846

tissue

TOTAL METALS

-1-

INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.

040JZ24701

: act:

ab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP15

atrix (soil/water): SOIL Lab Sample ID: S115006A-11

evel (low/med): LOW Date Received: 07-AUG-2001

Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.026	B		CV

olor Before: Clarity Before: Texture:

olor After: Clarity After: Artifacts:

omm~nts:

tissue

TOTAL METALS

-1-

INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.

040JZ31601

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP15

Matrix (soil/water): SOIL Lab Sample ID: S115006A-15

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.052	B		CV

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments:

tissue

TOTAL METALS

-1-

INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.

040NZ23702

.tract:

Lab Code: STLSAV   Case No.:   SAS No.:   SDG NO.: NASP15

Matrix (soil/water): SOIL   Lab Sample ID: S115006A-10

Level (low/med): LOW   Date Received: 07-AUG-2001

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.032	B		CV

.or Before: Clarity Before: Texture:

.or After: Clarity After: Artifacts:

m ;

Sediment Analytical Results

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.
040MZ13002

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP14

Matrix (soil/water): SOIL Lab Sample ID: S115006-10

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 83.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	210			P
7440-36-0	Antimony	0.46	U		P
7440-38-2	Arsenic	0.48	U		P
7440-39-3	Barium	0.47	B		P
7440-41-7	Beryllium	0.014	B		P
7440-43-9	Cadmium	0.055	U		P
7440-70-2	Calcium	110			P
7440-47-3	Chromium	1.4			P
7440-48-4	Cobalt	0.088	U		P
7440-50-8	Copper	0.40	B		P
7439-89-6	Iron	310			P
7439-92-1	Lead	0.82			P
7439-95-4	Magnesium	250			P
7439-96-5	Manganese	2.4			P
7439-97-6	Mercury	0.0050	U		CV
7440-02-0	Nickel	0.20	B		P
7440-09-7	Potassium	98	B		P
7782-49-2	Selenium	0.39	U		P
7440-22-4	Silver	0.077	U		P
7440-23-5	Sodium	1600			P
7440-28-0	Thallium	0.49	U		P
7440-62-2	Vanadium	0.68	B		P
7440-66-6	Zinc	0.73	B		P

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

30

Comments: Total metals

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.
040MZ21602

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP14

Matrix (soil/water): SOIL Lab Sample ID: S115006-9

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 25.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	13000			P
7440-36-0	Antimony	1.7	U		P
7440-38-2	Arsenic	11			P
7440-39-3	Barium	11			P
7440-41-7	Beryllium	0.70	B		P
7440-43-9	Cadmium	2.5			P
7440-70-2	Calcium	2700			P
7440-47-3	Chromium	87			P
7440-48-4	Cobalt	2.3	B		P
7440-50-8	Copper	31			P
7439-89-6	Iron	23000			P
7439-92-1	Lead	81			P
7439-95-4	Magnesium	6500			P
7439-96-5	Manganese	100			P
7439-97-6	Mercury	0.24			CV
7440-02-0	Nickel	8.8	B		P
7440-09-7	Potassium	2400			P
7782-49-2	Selenium	1.4	U		P
7440-22-4	Silver	0.30	B		P
7440-23-5	Sodium	25000			P
7440-28-0	Thallium	1.8	U		P
7440-62-2	Vanadium	26			P
7440-66-6	Zinc	140			P

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments: Total Metals

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.
040NZ21602

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP14

Matrix (soil/water): SOIL Lab Sample ID: S115006-15

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 27.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.27			CV

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments: Total metal

40

STL-Savannah

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.
040MZ23702

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP14

Matrix (soil/water): SOIL Lab Sample ID: S115006-14

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 83.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.010	B		CV

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments: Total metal

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.

040MZ24702

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP14

Matrix (soil/water): SOIL Lab Sample ID: S115006-17

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 16.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.26			CV

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments: Total metals

Form I - IN

SW-846

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.

040MZ24402

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP14

Matrix (soil/water): SOIL Lab Sample ID: S115006-16

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 75.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.0061	U		CV

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

42

Comments: Total metal

TOTAL METALS

-1-

INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.

040MZ31602

Contract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP14

Matrix (soil/water): SOIL Lab Sample ID: S115006-12

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 77.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.0054	U		CV

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

Comments: Total metal

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.
040MZ40102

ntract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP14

Matrix (soil/water): SOIL Lab Sample ID: S115006-13

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 83.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-97-6	Mercury	0.0055	U		CV

Color Before: Clarity Before: Texture:

Color After: Clarity After: Artifacts:

mments: Total metal

TOTAL METALS
-1-
INORGANIC ANALYSIS DATA SHEET

SAMPLE NO.
040NZ23702

ontract:

Lab Code: STLSAV Case No.: SAS No.: SDG NO.: NASP14

Matrix (soil/water): SOIL Lab Sample ID: S115006-11

Level (low/med): LOW Date Received: 07-AUG-2001

% Solids: 79.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	3200			P
7440-36-0	Antimony	0.44	U		P
7440-38-2	Arsenic	1.0	B		P
7440-39-3	Barium	3.2			P
7440-41-7	Beryllium	0.064	B		P
7440-43-9	Cadmium	0.053	U		P
7440-70-2	Calcium	1200			P
7440-47-3	Chromium	3.5			P
7440-48-4	Cobalt	0.53	B		P
7440-50-8	Copper	1.5	B		P
7439-89-6	Iron	2800			P
7439-92-1	Lead	11			P
7439-95-4	Magnesium	520			P
7439-96-5	Manganese	11			P
7439-97-6	Mercury	0.011	B		CV
7440-02-0	Nickel	1.0	B		P
7440-09-7	Potassium	160			P
7782-49-2	Selenium	0.38	U		P
7440-22-4	Silver	0.074	U		P
7440-23-5	Sodium	1300			P
7440-28-0	Thallium	0.47	U		P
7440-62-2	Vanadium	7.3			P
7440-66-6	Zinc	4.1			P

Offsite Background sample

Color Before: Clarity Before: Texture:

32

Color After: Clarity After: Artifacts:

mments: Total metals

Appendix B

Residue Effects of Mercury in Fish

NOAA, March 26, 2001

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OFFICE OF RESPONSE & RESTORATION
COASTAL PROTECTION AND RESTORATION DIVISION
c/o U.S. Environmental Protection Agency , Region 4
Waste Management Division
61 Forsyth Street, Atlanta, GA 30303

TECHNICAL MEMORANDUM

SUBJECT: Residue-Effects of Mercury in Fish

BY: Tom Dillon

DATE: March 26, 2001

1. Background

Mercury is a toxic and persistent bioaccumulative chemical found at many hazardous waste sites. Mercury poses risk to fish by two exposure routes; 1) direct exposure to abiotic media (sediment and water) and 2) the ingestion of contaminated prey. Risk posed by the first route is typically evaluated in ecological risk assessments by screening/refining Contaminants of Potential Concern (COPCs) and, if appropriate, toxicity tests with site-specific media. Ecological risk due to the direct exposure to abiotic media is not addressed in this memorandum.

Mercury accumulates in aquatic biota and may biomagnify to higher trophic levels due to the selective retention of methylated mercury. Quantifying this exposure for ecological risk assessments is usually accomplished using food web models. Models directly link abiotic media that may require remediation (e.g., sediments) to the risk estimates. Collecting higher trophic level fish to address this exposure pathway is usually undesirable because; 1) fidelity to the site may be low and/or highly uncertain and 2) links to potential remedial actions with site media are lost.

A mercury food web model for the red drum (*Sciaenops ocellatus*) has been cooperatively developed by natural resource trustees, EPA and responsible parties at an estuarine Superfund site on the Texas Gulf Coast (Evans and Engel, 1994). This model predicts whole body methylmercury concentrations in red drum arising from the exclusive ingestion of contaminated prey items. Red drum exposure to mercury-contaminated water and sediment are ignored in the model.

Interpreting the biological significance of mercury residues in fish requires an examination of residue-effects information published in the scientific literature. Conceptually, residue-effects information is similar to dose-response curves generated in toxicological experiments. At low doses, no effects are observed. At high doses, effects are severe and frequently encountered. Between the low and high doses, adverse effects may be less severe.

2. Purpose

The purpose of this memorandum is to summarize the technical basis for developing a No Observable Adverse Effect Level (NOAEL) and a Lowest Observable Adverse Effect

Level (LOAEL) for mercury in fish tissue. The NOAEL represents the very low end of the conceptual dose-response curve while the LOAEL signifies that region of the curve where adverse effects are beginning to emerge. Together, the NOAEL and LOAEL represent the threshold response for assessment endpoints involving fish. As with any ecological assessment endpoint, protective levels emerging from the threshold response may become Remedial Goal Objectives (RGOs) at hazardous waste sites and subsequent clean-up levels.

3. **Approach**

Beckvar et al. (1996) reported a tabular summary of mercury residue-effects information available for fish. Individual papers identified through literature searches and compilations developed by the US EPA (Jarvinen and Ankley, 1999) and the US Army Corps of Engineers Environmental Residue-Effects Database (www.wes.army.mil/el/ered) were obtained and critically reviewed. The tabular summary of Beckvar et al. (1996) has recently been updated (Table 1). Papers included represent a general bias for investigations reporting whole body concentrations, laboratory exposures, and ecologically important endpoints (e.g., survival, growth, reproduction, behavior). Because the purpose of this memorandum is to identify a NOAEL and LOAEL, those papers reporting both effects and no effects in whole body fish tissue were evaluated further (Table 2).

4. **Analysis**

Whole body tissue concentrations associated with no effects range between 0.02 μg/g and 2.7 μg/g with a median highest effect value of 0.15 μg/g (Table 2). Mercury residues associated with the lowest adverse effects ranged between 0.04 μg/g and 19 μg/g with a median value of 0.30 μg/g. Within each set of published results, the difference between the highest no effect and lowest effect level was small. The difference between the two median values is two-fold. This suggests a narrow threshold response in mercury-exposed fish. Lower concentrations are generally observed in investigations involving early life stage exposures (egg, embryo, larvae, fry).

5. **Discussion**

In their review of mercury effects on freshwater fish, Weiner and Spry (1996) suggest whole body concentrations of 5-10 μg/g in adult fish are associated with sublethal or lethal effects. They estimate a slightly lower no-observed-effect concentration of 3 μg/g. However, they note that adverse effects on early life stages of fish occur at much lower tissue concentrations (0.07-0.10 μg/g). This is consistent with the observations of many investigators that early life stages are more sensitive to contaminant exposure than adults. In concluding their review, Weiner and Spry (1996) posit that the greatest risk to fish populations is the maternal transfer of mercury to developing eggs and embryos.

Mercury is a neural toxin that exerts its adverse effects at the molecular level by tightly binding with sulfhydral moieties in proteins (enzymes and cellular membranes). This biochemical effect is often manifested at the organismal level by altered behavior. Two publications have emerged since the Weiner and Spry review (1996) which report concomitant mercury residues and behavioral effects. Fjeld et al. (1998) exposed grayling embryos (*Thymallus thymallus*) to methylmercury for 13 days. Tissue residues in exposed embryos ranged between 0.09 µg/g and 3.80 µg/g, wet weight (Table 2). Exposure was terminated soon after hatching and fish raised to adulthood under normal, controlled conditions. *Three* years after exposure as embryos, adult fish were tested in the laboratory for their ability to compete for and capture live prey. Fish with embryo mercury residues between 0.30 and 3.8 µg/g were significantly impaired in their ability capture and compete for live prey. Embryos in the control and lowest (unaffected) exposure group had mercury residues of 0.01 µg/g and 0.09 µg/g, respectively. This investigation demonstrates that fish feeding behavior in adults can be permanent impaired following short-term mercury exposure as embryos. Embryo mercury residues in the lower exposure treatments reported by Fjeld et al. (1998), 0.09-0.3 µg/g, are very similar to the early life stage effects range suggested by Weiner and Spry (1996); i.e., 0.07-0.10 µg/g.

Altered fish behavior (leading to significant mortalities) was also reported in a recent paper by Matta et al. (2001). *Fundulus heteroclitus* were chronically exposed to methylmercury in food then induced to spawn. Spawning males with tissue concentrations equal to or greater than 0.47 µg/g exhibited altered behavior (extreme aggression or pacificity) which led to significant mortalities in the passive fish. Survival of fish with slightly lower residues, 0.20 µg/g or less, was unaffected. In both the Matta et al. (2001) and Fjeld et al. (1998) investigations, the differences between the highest no effect and lowest effect concentrations were very small (0.09 µg/g vs 0.3 µg/g and 0.20 µg/g vs 0.47 µg/g).

When attempting to identify residue-based NOAELs and LOAELs from laboratory studies, it is appropriate to consider regional or site-specific background information. These data provide independent perspective, especially regarding the appropriateness of a potential NOAEL. That is, if tissue concentrations in fish collected from "clean" background locations approximate the NOAEL, one's confidence in the proposed NOAEL increases. The NOAEL-to-background comparison is also important from the risk management/remedial action perspective. Actions are rarely taken for risks at or below background.

In a national study of chemical residues in fish, field samples were collected by EPA at hazardous waste sites as well as background locations (EPA 1992). In fish from the EPA Region 4 background locations, whole body mercury was detected in 10 of 11 samples. Concentrations ranged between 0.03 and 0.29 µg/g wet weight with a median value of 0.17 µg/g (Table 3). This median background concentration is almost identical to the median highest no effect value (0.15 µg/g) observed in laboratory toxicity studies (Table 2).

Two independent investigations provide fish tissue reference data for the LCP site. Matta et al. (1998) reported mean mercury concentrations in fish collected at two reference stations in the Crescent River to be 0.02 and 0.04 µg mercury/g dry weight. Using percent solids reported in Matta et al. (1998, Table 3.4), these mean concentrations would be 0.005-0.01 µg mercury/g wet weight. Similar low tissue concentrations (0.023 µg mercury/g wet weight) were reported by Sprenger et al. (1997) for forage fish collected in the Troup Creek and the Little Satilla River reference locations for the LCP project.

6. **Conclusions**

a. Laboratory toxicity studies indicate whole body mercury tissue concentrations associated with no effects approximate a median value of 0.15 μg/g wet weight (Table 2). This concentration is nearly identical to the median concentration (0.17 μg/g wet weight) found in whole fish from background locations throughout EPA Region 4 (Table 3). These toxicologically-based and background concentrations are about an order of magnitude greater than those observed for fish collected at multiple reference stations for the LCP site, Brunswick, GA.

b. Laboratory toxicity studies indicate lower whole body mercury tissue concentrations associated with adverse effects range between 0.04 μg/g and 19 μg/g with a median value of 0.30 μg/g wet weight (Table 2). More frequent, severe adverse effects in fish are likely as tissue concentrations increase.

c. Within individual investigations, the difference between the no effects and lowest effect tissue concentration is small (Table 2) suggesting a sharp threshold response for mercury-contaminated fish.

d. As with most environmental contaminants, early life stages of fish (eggs, embryos, fry) are generally more sensitive to mercury than adults. Short-term mercury exposure to early life stages can have permanent, adverse effects on successful feeding behavior later in life.

e. Maternal transfer of mercury to early life stages represents a viable exposure pathway.

f. Laboratory toxicity studies indicate the lowest whole body mercury tissue concentrations associated with adverse effects in fish embryos approximate 0.07-0.1 μg/g wet weight (Weiner and Spry 1996, Fjeld et al. 1998).

7. **Uncertainties in Selecting a NOAEL and a LOAEL**

Many sources of uncertainty are embedded in any residue-effects analysis (see discussion in Jarvinen and Ankley 1999). Most uncertainties are associated with laboratory toxicity studies generating the biological effects and chemical residue data. Specific sources of uncertainty include interspecific contaminant sensitivity, life stage differences, exposure regimes (e.g., duration, food vs. water), endpoints examined and analytical chemistry. We attempted to reduce some of these uncertainties by focusing on published investigations that employed longer exposures, examined biologically important endpoints such as growth, reproduction, behavior and reported whole body tissue concentrations. Of these sources of uncertainty, differences in life stage appear to have the largest quantitative impact on mercury residue-effects in fish.

In selecting a NOAEL and LOAEL, it is useful to discuss the uncertainties associated with the low, middle and high portions of the conceptual dose-response curve. At the lower, no effects end of the curve, 0.15 μg/g wet weight appears to be a representative concentration (Table 2). Certainty in this value is increased by two independent lines of evidence. One, the 0.15 µg/g value closely mirrors median whole fish concentration at background locations in EPA Region 4 (0.17 µg/g wet weight). Two, mercury in fish collected at LCP reference stations are about an order of magnitude lower (≅0.01-0.02 µg/g wet weight).

Uncertainty at the high end of the dose-response curve is inherently low because adverse effects are more frequent and typically severe (e.g., death). In their review, Weiner and Spry (1996) conclude that adverse effects in fish are consistently observed at whole body tissue concentrations between 5 and 10 µg/g wet weight.

Greater uncertainty is encountered in the middle of the dose-response curve. This is especially true at the lower end of the curve where the LOAEL resides. This difficulty is compounded by the observation in many investigations that the difference between no effects and effects may be small. If we accept 0.15 µg/g wet weight to be a reasonably certain NOAEL, the median lowest effects level of 0.30 µg/g wet weight (Table 2) can be considered a reasonable, albeit less certain, LOAEL. The 0.30 µg/g wet weight value represents most of the lowest effects tissue concentrations reported in Table 2. Based on its guidance for ecological and human health risk assessments, EPA generally defers to the more conservative, environmentally protective toxicity reference values. A LOAEL of 0.30 µg/g wet weight for mercury effects on fish is consistent with that guidance. It is interesting to note that 0.30 µg/g wet weight is also the tissue concentration EPA recently (January 2001) recommended fish not exceed to be protective of human health (www.epa.gov/waterscience/standards/methylmercury)..

NOAEL and LOAEL are single points on a toxicological dose-response continuum. One can always argue that a specific value could be slightly higher (less protective) or slightly lower (more protective) based on the available data and accompanying uncertainty. However, the values developed above and recommended below appear consistent with information presented in the scientific literature as well as EPA guidance for ecological risk assessments.

8. Recommended NOAEL and LOAEL for Residue-Effects of Mercury in Fish

a. NOAEL: 0.15 µg/g wet weight

b. LOAEL: 0.30 µg/g wet weight

c. Use the above values to interpret whole body adult fish residues predicted from higher trophic level food web modeling (Evans and Engel 1994) conducted for the ecological risk assessment at the LCP site.

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Table 1. A summary of mercury residue-effects literature for fish.									
Fish Species	**Life Stage**	**Exposure**	**Duration**	**Endpoint**	**Tissue Analyzed**	**No Effect Residue (ug/g, ww)**	**Effects Residue (ug/g, ww)**	**Effect Description**	**Reference**
Rainbow trout *Oncorhynchus mykis*	adult through spawning	$HgCl_2$ 0.24 µg/l flow-thru	400-528 days	mortality, teratogenic	egg gonad	0.04 0.09	0.26-3.67 0.49-4.57	significant reduction in alevin survival (4-day post hatch); significant increase in teratogenic effects	Birge et al. 1979
"	eyed eggs to 10-day old fry	$HgCl_2$ 0.18-107 µg/l in sediments + 0.25-6.4 µg/l in overlying water	20 days = 10-day pre- and 10-day post-hatching	mortality	whole body of 10-day old fry	0.02	0.04 0.3 0.9	55% mortality at 10 days 77% mortality at 10 days 100% mortality at 10 days	Birge et al. 1979
"	Developing embryo	$HgCl_2$ 0.1-0.14 µg/l flow-thru	8 days	mortality	eggs	0.02 - 0.04	0.07 0.1	17-21% mortality at 4 days 100% mortality at 8 days	Birge et al. 1979
"	fingerlings	CH_3HgCl in food	84 days	growth, behavior, physiology	whole body		10-30 30-35	diminished growth and appetite; darkened skin and lethargy	Rodgers and Beamish 1982
"	fry-juvenile	total mercury 50 µg/g in food	270 days	growth, behavior	brain liver muscle whole body	 0.2	16-30 26-68 20-28 19	darkened skin; diminished appetite, visual acuity, and growth; loss of equilibrium	Matida et al. 1971
"	fingerlings	CH_3HgCl 4-24 µg/g in food	105 days	growth, histology, biochemistry	muscle	<0.2 12	12-24 19-24	hyperplasia of gill epithelium increased blood packed cell volume, reduced growth	Wobeser 1975
"	subadult	CH_3HgCl 4 µg/l flow-thru	30-98 days	mortality, behavior	brain liver muscle		7-32 32-114 9-52	diminished appetite and activity	Niimi and Kissoon 1994
"	subadult	CH_3HgCl 9 µg/l flow-thru	12-33 days	mortality, behavior	whole body		4-27	diminished appetite and activity	Niimi and Kissoon 1994

Fathead minnow *Pimephales promelas*	Fry fed dry food	$HgCl_2$ 0.31-4.51 µg/l flow-thru	60 days	survival, growth, development	whole body	0.12 - 0.8	1.3 4.2	retarded larval growth retarded larval growth, 50% mortality, spinal curvature	Snarski and Olson 1982
"	Fry fed live food	$HgCl_2$ 0.26-3.7 µg/l flow-thru	60 days	survival, growth, development	whole body	0.22 - 2.64	4.7-7.60	retarded larval growth; control growth better on live food	Snarski and Olson 1982
"	Full life cycle on live food + F1 larvae	$HgCl_2$ 0.26-3.7 µg/l flow-thru	41 weeks	survival, growth, reproduction	whole body F0 adult fish	0.32	1.36 - 2.84 4.47 - 18.8	reduced growth in F0 females and F1 fry spawning ceased; external sex. features absent	Snarski and Olson 1982
Brook trout *Salvelinus fontinalis*	continuous exposure of F0,F1 fish + F2 embryos	CH_3HgCl 0.29 µg/l aqueous	273 days	mortality, growth, reproduction	brain liver gonad F0 whole body	5 8 3 2.7		no apparent effects	McKim et al. 1976
"	continuous exposure of F0,F1 fish + F2 embryos	CH_3HgCl 0.93 µg/l aqueous	273 days	mortality, growth, behavior	brain liver gonad F0 whole body		17 24 12 5-7	increased mortality, decreased growth, lethargy, and deformities in F1 embryos, no spawning	McKim et al. 1976
"	continuous exposure of F0,F1 fish + F2 embryos	CH_3HgCl 0.93 µg/l aqueous	273 days	mortality	F2 embryo		2.2	deformed embryos; 100% mortality 3 weeks after hatching	McKim et al. 1976
"	continuous exposure of F0,F1 fish + F2 embryos	CH_3HgCl 2.9 µg/l aqueous	273 days	mortality	F1 embryo		12.5	Deformed embryos; no hatching observed	McKim et al. 1976
Channel catfish *Ictalurus punctatus*	Embryo to 4-day old larvae	$HgCl_2$ 0.3µg/L flow-thru	10 days	mortality	eggs		0.014-0.34	Survival reduced in dose-dependent manner. Median lethal concentration at 4 days post-hatching corresponds to a tissue concentration of 0.06 ug/g ww.	Birge et al. 1979
Walleye *Stizostedion vitreum vitreum*	1 year old	Methylmercury 5-13 µg/g in food	42-63 days	mortality, behavior, physiology	brain liver muscle	 <1	3-6 6-14 5-8	emaciation; loss of locomotion, coordination and appetite.	Scherer et al. 1975
"	1 year old	Methylmercury 5-13 µg/g in food	240-314 days	mortality, behavior, physiology	brain liver muscle	 <2.5	15-40 18-50 15-45	88% mortality; emaciation; poor locomotion, coordination and appetite.	Scherer et al. 1975
"	juveniles	methylmercury 0.14-1 µg/g	180 days	development, physiology	whole body (minus viscera)	0.06*	0.25 2.37	testicular atrophy and impaired development, impaired immune function testicular atrophy and impaired development,	Friedmann et al. 1996

		in food						impaired immune function; impaired growth in males	

Striped mullet *Mugil cephalus*	juvenile	CH_3HgCl 1 µg/l aqueous CH_3HgCl 10-20 µg/l aqueous	10,13 days 7,10,13 days	physiology	whole body	<0.1	0.3 5.0	fin regeneration inhibited fin regeneration inhibited	Weis and Weis 1978
Grayling *Thymallus thymallus*	embryos exposed, 3 yr adults tested	CH_3HgCl 0.16-20 µg/l aqueous	13 days until hatching	behavior, hatching, development	whole body (fry)	0.09	0.27 0.63 3.8	adult foraging efficiency, prey capture reduced adult foraging efficiency, prey capture reduced adult foraging efficiency, prey capture reduced; fry exhibit scoliosis, jaw deformities; embryos hatching reduced	Fjeld et al. 1998
Killifish *Fundulus heteroclitus*	adults exposed, 2 generations followed	CH_3HgCl 0.5-54 µg/g in food of F0 Adults	42 days F0 only	mortality, growth, reproduction, sex ratios	whole body F0 adults F1 eggs	0.2 <0.02	0.47 1.0-1.1 11-12 0.01 0.63	Abnormal behavior & reduced survival in F0 males; Reduced F1 fry growth Abnormal behavior & reduced survival in F0 males; Reduced F1 fry growth; altered F1 sex ratios Abnormal behavior & reduced survival in F0 males; Reduced F1 fry growth; altered F1 sex ratios; reduced fertilization success in F1 altered sex ratio in F1 altered sex ratio in F1, reduced fertilization success in F1 adults	Matta et al. 2001

Table 2. Residue-effects literature (from Table 1) reporting both effects and no effects in whole body fish tissue.

Reference	Life Stage Chemically Analyzed	No Effect Concentrations (mg/kg ww)	Effects Concentrations (mg/kg ww)	Types of Effects Measured	Exposure Regime
Birge et al. 1979	10-day old fry	0.02	0.04 - 0.9	survival	8-500 days water, sediment
Fjeld et al. 1998	embryo	0.09	0.3 - 3.8	hatching, fry deformities, 3 year old adult prey capture and foraging efficiency	13 days aqueous
Matida et al. 1971	fry/juvenile	0.2	19	growth, behavior, vision	270 days food
Weis and Weis 1978	juvenile	<0.1	0.3	caudal fin regeneration	7-13 days aqueous
Friedmann et al. 1996	adult (less viscera)	0.06	0.25 - 2.37	growth and gonadal development	180 days food
Matta et al. 2001	adult	0.2	0.4 - 12	survival, behavior, reproduction	42 days food
Snarski and Olso 1982	juvenile/adult	0.3 - 0.8	1.2 - 4.2	growth and reproduction	30-60 days, 41 weeks aqueous
McKim et al. 1976	adult	2.7	5-7	survival, growth, reproduction	147 weeks, 2 generations aqueous
Median Highest NOAEL =		**0.15**	**0.30**	**= Median LOAEL**	

Table 3. Concentrations of mercury (ug/g wet weight) in whole fish collected from background stations in USEPA Region 4. Information taken from Appendix D of USEPA Report 823-R-92-008 (National Study of Chemical Residues in Fish, 1992).									
From Table D-1				From Appendix D-5			From Appendix D-6		
						Hg			
				Fish		Conc.	%	Wet Wt.	Date
Episode	**Waterbody**	**Location**	**ST**	**Common Name**		**(ug/g)**	**Lipid**	**(g)**	**Collected**
3169	Inland Lake	Blout Co.	AL	Black Redhorse	WB	0.16	11.3	20.1	8710
3177	Chattahoochee R.	Gainsville	GA	Carp	WB	0.03	6.7	20.16	8709
3178	Chattooga R.	Clayton	GA	North.Hogsucker	WB	0.23	3.03	20.32	8709
3179	Chestatee R.	above Lake Lanier	GA	Golden Redhorse	WB	0.24	8.2	20.08	8709
2139	Cattaloochee Creek	Cattaloochee	NC	Carp	WB	0.08	7.9	19.96	8705
3166	Nanthalia R.	Macon Co.	NC	White sucker	WB	0.29	8.2	20.04	8410
3187	St. Helena Sound		SC	Summer Flounder	WP	0.05*	2.8	20.05	8711
2301	Buffalo R.	Flatwoods	TN	Sm. Bass	WB	0.18	NM	NM	8501
2301	Buffalo R.	Flatwoods	TN	Bluegill	WB	0.20	NM	NM	8501
2301	Buffalo R.	Flatwoods	TN	Black Cappie	WP	0.11	NM	NM	8501
2301	Buffalo R.	Flatwoods	TN	Rock Bass	WP	0.14	2.1	20	8501
				Median Conc.		**0.17**			

WB=Whole Body   WP=Whole Predator   NM=not measured

* Mercury detection limit of 0.05 ug/g was used for this non-detected sample

Common Fish Name	**Scientific Name**
Black Redhorse	*Moxostoma duquesnei*
North.Hogsucker	*Hypentelium nigricans*
Golden Redhorse	*Moxostoma erythrurum*
Carp	*Cyprinus carpio*
White sucker	*Catostomus commersoni*
Summer Flounder	*Paralichthys dentatus*
Sm. Bass	*Micropterus dolomieui*
Bluegill	*Lepomis macrochirus*
Black Cappie	*Pomoxis nigromaculatus*
Rock Bass	*Ambloplites rupestris*